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(54) **INTERACTIVE DENTAL RESTORATIVE NETWORK**

(75) Inventors: **Maryann Lehmann**, Darien, CT (US); **Curtis A. Vock**, Boulder, CO (US)

(73) Assignee: **Shade Analyzing Technologies, Inc.**, Darien, CT (US)

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Related U.S. Application Data

(63) Continuation of application No. 09/523,152, filed on Mar. 10, 2000, now Pat. No. 6,575,751, which is a continuation of application No. 09/443,368, filed on Nov. 19, 1999, now abandoned, which is a continuation of application No. 09/411,920, filed on Oct. 4, 1999, now abandoned.

(60) Provisional application No. 60/106,920, filed on Nov. 3, 1998, provisional application No. 60/109,299, filed on Nov. 19, 1998, provisional application No. 60/120,596, filed on Feb. 18, 1999, and provisional application No. 60/120,620, filed on Feb. 18, 1999.

60/120,612

(51) **Int. Cl.**[7] **A61C 5/10**

(52) **U.S. Cl.** **433/223**

(58) **Field of Search** 433/26, 215, 223; 382/165; 356/402, 73, 419

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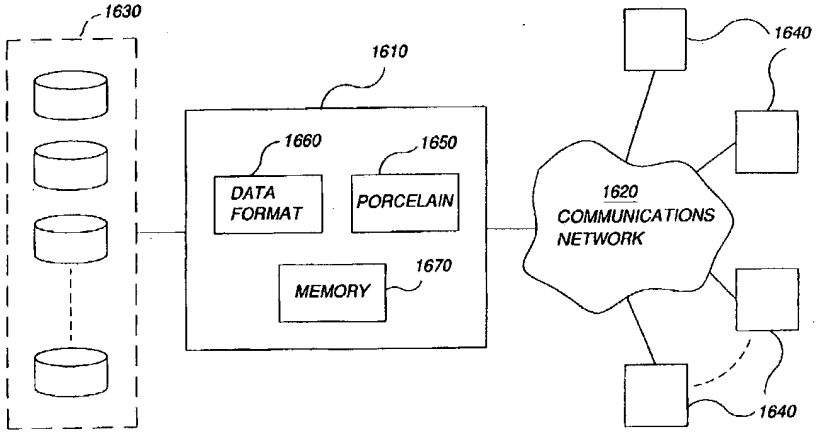
Primary Examiner—Todd E. Manahan
(74) *Attorney, Agent, or Firm*—Winston & Strawn LLP

(57) **ABSTRACT**

The invention relates to a method for restoration of a patient's tooth. An electronic image of a patient's tooth or tooth preparation is generated in a dentist's office by the dentist. The image includes color information of the tooth preparation or of the patient's tooth shade. The electronic image is forwarded to a dental laboratory by direct computer link or e-mail. A technician at the laboratory evaluates the image and suggests restorative options to the dentist, including whether further tooth preparation is required. The technician also selects the appropriate restoration tooth shade(s) so that the dental prosthesis matches the color of the patient's tooth. The laboratory then manufactures the prosthesis utilizing a plurality of porcelain coatings. If desired, an image of the prosthesis can be generated in the laboratory and forwarded to the dentist for verification of color and/or fit prior to finalizing manufacture of the prosthesis.

37 Claims, 9 Drawing Sheets



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INTERACTIVE DENTAL RESTORATIVE NETWORK

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of application Ser. No. 09/523,152 filed Mar. 10, 2000 now U.S. Pat. No. 6,575,751, which application is a continuation of application Ser. No. 09/443,368 filed Nov. 19, 1999, now abandoned, which application is a continuation of application Ser. No. 09/411,920 filed Oct. 4, 1999, now abandoned.

This application claims the benefit of U.S. provisional applications Nos. 60/106,920 filed Nov. 3, 1998, 60/109,299 filed Nov. 19, 1998, 60/120,596 filed Feb. 18, 1999 and 60/120,620 filed Feb. 18, 1999.

60/120,612

TECHNICAL FIELD

The invention is directed to methods, systems and devices for dental restoration wherein communication between the dentist and restoration laboratory are held in real time to discuss, finalize and optimize a treatment plan for a patient. More specifically, the invention is directed to an interactive computer-based system and method to enable the dentist and restoration laboratory to analyze color images of one or more teeth and teeth preparation so that a replacement tooth or crown can be particularly designed to precisely match the tooth that is to be replaced in certain clinical or cosmetic procedures.

BACKGROUND OF THE INVENTION

Restorative dentistry is the art and science of replacing or restoring lost tooth structure. The amount of tooth structure to be replaced determines what path the operator takes—whether the restoration will be a crown, bridge, inlay, onlay or direct restoration (i.e., a filling). The choice of that path in the past was more simple, due to the limited number of materials and techniques available. For example, U.S. Pat. Nos. 5,766,006 and 5,961,324 describe methods and systems for determining tooth color information based upon digital images provided by a camera and then matching the color of the restoration article (i.e., dental prosthesis) with the determined tooth color. In recent years, however, with the advent of new materials and concepts, treatment choices have expanded in a phenomenal way. Dentists are now facing an overload of information in trying to decide which materials and procedures are the best suited for their particular cases. What the state-of-the-art practitioner needs is a source to be able to go to, at a moment's notice, that will be able to aid him and his lab if necessary in treatment planning and delivering the best restorative dentistry possible, utilizing the most appropriate materials available today. The present invention now satisfies this need.

SUMMARY OF THE INVENTION

The invention relates to an interactive dental restoration method between a dentist and a dental restoration laboratory. The basic steps of this method include identifying a dental restoration need in a patient; designing a preliminary treatment plan that includes design criteria for preparation of a dental prosthesis to be placed in the patient to satisfy the dental restoration need; transmitting the preliminary treatment plan via a communications network to a dental restoration laboratory; and communicating a final treatment plan, including modifications to the preliminary treatment plan where necessary, to the dentist. Typically, the final treatment plan includes information about materials for preparing a dental prosthesis that satisfies the design criteria, and the dental prosthesis is then prepared for placement in the patient. This method enables optimization of the dental restoration with significant savings in time and effort for the dentist, dental technician and the patient.

Generally, the dentist prepares the preliminary treatment plan and the design criteria include digital image representations of the dental restoration need. Thereafter, the preliminary treatment plan can be forwarded to and evaluated by the laboratory before a final treatment plan is formulated and communicated to the dentist. The step of transmitting and evaluating the plan are codirected over the communications network. Thus, the final treatment plan is not implemented in the patient until after interim preparation information is transmitted to the laboratory and confirmed, thus avoiding rework or revision after the plan has been implemented.

Advantageously, the design criteria or the modifications thereto include proposed decay excavation, tooth preparation, or dental prosthesis color. When a dental prosthesis such as a crown, bridge or replacement tooth is needed, the method includes verifying that the dental prosthesis is prepared according to the final treatment plan prior to placement of the dental prosthesis in the patient. In order to obtain the best color match of the dental prosthesis with the patient's teeth, the digital image representations include REAL IMAGE and REFERENCE IMAGES and the modifications include correlation of a color selection for the dental prosthesis to match the REAL IMAGE. Furthermore, the design criteria can include tooth preparation and proposed decay excavation, and the method further comprises a communication of a confirmation or modification, from the laboratory, of the acceptability of one or more of the proposed design criteria.

The invention also relates to a computer-based dental restoration system comprising a network server having a database storing information about materials, procedures and preparations concerning dental restoration prosthesis; a communications network providing access to the network server; and one or more computers at a dental office accessing information stored at the database over the communications network and displaying the information in a humanly readable format. Preferably, the communications network is the Internet, and the information stored in the database comprises preparation diagrams, reduction dimensions, margin design and burs for specific dental restoration prostheses.

Advantageously, the database further stores information concerning one or more patients having dental restoration needs. Also, the network server further comprises application programs for enabling users to query the database regarding specific materials or procedures concerning dental restoration prostheses for confirmation, verification, modification or evaluation of the same, with the one or more computers at the dental office receiving answers from the database to such queries. If desired, a printer located at the dental office can be used to print these answers for use by the dentist in carrying out the treatment plan.

The dental restoration laboratory also includes at least one computer that has access to the network server and the computer(s) at the dental office over the communications network. Preferably, the system includes a digital camera for taking digital images of the patient's teeth that are in need of dental restoration and a communication link for transmitting the digital images to the computer(s) at the dental

What is claimed is:

1. A method for restoration of a patient's tooth which comprises:

generating an electronic image of a patient's tooth in a dentist's office, wherein the image includes color information representative of the patient's tooth shade;

designing a preliminary treatment plan for addressing the dental needs of the patient; and

forwarding the electronic image to a dental laboratory, wherein a technician evaluates the image and, if necessary, suggests restorative options to the dentist and the dentist and the dental restoration laboratory simultaneously have access to the electronic image.

2. The method of claim 1, wherein the dentist forwards to the laboratory the preliminary treatment plan along with the electronic image, the laboratory technician provides feedback on the treatment plan, and the dentist and the technician simultaneously have access to the preliminary treatment plan and the feedback.

3. The method of claim 2, wherein the image includes information about the patients' tooth color, the preliminary treatment plan includes a determination of at least one matching shade of material to restore the tooth, and the technician either confirms the dentist's determination of restoration material shade or suggests an alternative shade.

4. The method of claim 3, which further comprises electronically storing color information representative of a plurality of tooth shades on a computer at the dentist office; and comparing the color information of the image with the stored tooth shade color information to identify one or more tooth shades having a combined color that corresponds to the patient's tooth shade before sending the identified color (s) to the laboratory.

5. The method of claim 4, wherein the image of the patient's tooth is automatically compared to the stored tooth shade color information electronically by the computer.

6. The method of claim 4, wherein the image of the patient's tooth is electronically displayed with color pixels to assist in determining the color of the patient's tooth shade.

7. The method of claim 6, wherein the patient's tooth shade as determined by selecting one or more pixels of the image, which pixels correspond to differential spatial locations of the patient's tooth, that provide similar color information and electronically comparing that color information with the stored tooth shade color information to determine the color of that portion of the patient's tooth.

8. The method of claim 7, wherein selection of the pixel(s) is repeated until a tooth shade color is determined for all spatial locations of the image of the patient's tooth, with the patient's tooth shade being determined by averaging the color information at selected pixel locations of the image before electronically comparing the averaged color information with the stored tooth shade color information.

9. The method of claim 4, which further comprises utilizing a digital camera to obtain the image of the patient's tooth and utilizing the same camera to obtain the color information of the tooth shades before electronically storing the color information.

10. A method for restoration of a patient's tooth which comprises:

generating an electronic image of a patient's tooth or tooth preparation in a dentist's office, wherein the image includes color information representative of the patient's tooth shade;

designing a preliminary treatment plan for addressing the dental needs of the patient; and

forwarding the electronic image to a dental laboratory by direct computer link or e-mail, wherein a technician evaluates the image and suggests restorative options to the dentist and the dentist and the dental restoration laboratory simultaneously have access to the electronic image.

11. A method for restoration of a patient's tooth which comprises:

generating an electronic image of a patient's tooth preparation in a dentist's office, wherein the image includes color information representative of the patient's tooth shade;

designing a preliminary treatment plan for addressing the dental needs of the patient; and

forwarding the electronic image and the preliminary treatment plan to a dental laboratory, wherein a technician evaluates the image and suggests restorative options to the dentist, including whether further preparation is required, and the dentist and the dental restoration laboratory simultaneously have access to the electronic image and the preliminary treatment plan.

12. The method of claim 11, wherein the dentist or technician accesses an interactive website to review step-by-step procedures to determine an appropriate restorative procedure and to obtain feedback for any specific dental needs for the patient's tooth.

13. The method of claim 11, wherein the laboratory technician suggests restoration materials and treatment modalities for completing the restoration of the patient's tooth.

14. The method of claim 13, wherein the dentist accesses an interactive website to obtain preparation information, identify tools to carry out the preparation, or to identity sources where tools or materials for use in the restoration may be obtained.

15. The method of claim 11, wherein the laboratory technician prepares a dental prosthesis; takes an image of the prosthesis; and compare the prosthesis image to the image provided by the dentist before the prosthesis is permanently placed in the patient.

16. The method of claim 15, wherein the laboratory manufactures the prosthesis utilizing a plurality of pore lain coatings.

17. The method of claim 15, wherein the image of the prosthesis provides color information that is compared to the image of the patient's tooth to confirm color matching.

18. An interactive dental restoration method between a dentist and a dental restoration laboratory which comprises:

identifying a dental restoration need in a patient;

creating a digitized image in computer readable format of at least a portion of a tooth of the patient;

transferring the digitized image to a software program on a computer;

creating a patient file on the computer containing the digitized image;

designing a preliminary treatment plan for addressing the dental needs of the patient;

enhancing the digitized image using the software program to create an enhanced image, and

adding text information to the image;

transmitting the preliminary treatment plan via e-mail using the software program over a communications network to a dental restoration laboratory; and

directly communicating between the dentist and dental restoration laboratory over the communications

network, wherein the dentist and dental restoration laboratory simultaneously have access to the enhanced digital image.

19. The method of claim **18**, wherein the enhancing step includes adjusting predetermined or user defined areas of the tooth image.

20. The method of claim **18**, wherein the enhancing step includes performing at least one filtering operation on the image.

internet — **21**. The method of claim **18**, wherein the communications network includes the (interact.)

22. The method of claim **18**, wherein the communications network includes a direct connection between the dentist and dental restoration laboratory.

23. The method of claim **18**, wherein the computer is a database including stored patient information for a plurality of patients.

24. The method of claim **23**, wherein the computer is located in the dentist's office.

25. The method of claim **18**, wherein the text information includes a label.

26. The method of claim **18**, wherein the text information includes prosthesis materials.

27. The method of claim **18**, wherein the design criteria includes digital image representations of dental restoration need.

28. The method of claim **18**, wherein the design criteria includes proposed decay excavation.

29. The method of claim **18**, wherein the design criteria includes tooth preparation information.

30. The method of claim **18**, wherein the design criteria includes prosthesis color information.

31. The method of claim **18**, further comprising the step of communicating a final treatment plan, including modifications to the preliminary treatment plan, if necessary, to the dentist.

32. An interactive dental restoration method between a dentist and a dental restoration laboratory which comprises:

identifying a dental restoration need in a patient,

designing a preliminary treatment plan for addressing the dental needs of the patient;

transmitting the preliminary treatment plan via a communications network to a dental restoration laboratory for evaluation by a technician, wherein the dentist and the dental restoration laboratory simultaneously have access to the preliminary treatment plan; and

communicating a final treatment plan, including the technician's modifications to the preliminary treatment plan, if necessary, to the dentist.

33. The method of claim **32**, wherein the dentist prepares the preliminary treatment plan and the design criteria include digital image representations of the dental restoration need.

34. The method of claim **33**, further comprising the step of evaluating the preliminary treatment plan at the laboratory by the technician and making changes before communicating the final treatment plan to the dentist.

35. The method of claim **34**, further comprising the steps of implementing the final treatment plan in the patient and transmitting interim preparation information to the laboratory for survey with confirmation prior to completing the final treatment plan.

36. The method of claim **35**, wherein the design criteria include tooth preparation and proposed decay excavation.

37. The method of claim **36**, further comprising the step of communicating a confirmation or modification of the acceptability of one or more of the proposed design criteria from the laboratory to the dentist.

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